# Estimation of avoidable sprays for bollworm management in Bt-cottons

S.S. Udikeri, S.B. Patil, A.M. Nadaf and B.M. Khadi
Agricultural Research Station, Dharwad Farm, Karnataka INDIA
Correspondence author ssudikeri@rediffmail.com

## ABSTRACT

*The number of avoidable sprays and savings in cost of protection in transgenic Bt cotton hybrids was worked out through field experimentation at the Agricultural Research Station, Dharwad Farm, Dharwad Karnataka, India during 2001-02. Three Bt cotton hybrids (MECH-12, MECH-184 and MECH-162) were used for investigations along with their non-Bt versions and checks (NHH-44 and DHH-11) replicated in a trial . The protection measures taken against sucking pests were common to all treatments and that for bollworm management were based only on economic thresholds. Three rounds of sprays were given against bollworms in non-Bt hybrids and checks as against only one spray in Bt-hybrids. The spray volume was uniform (1000 l/ha) to all genotypes. The incidence of* Helicoverpa armigera *larvae was least 0.45/plant in MECH-184 Bt as against 1.38/ plant in MECH-184 non-Bt. This difference was significant and averaged trend was shown with other Bt hybrids also. Despite of three applications of insecticides the incidence of* Helicoverpa *and pink bollworm was higher in non-Bt hybrids and checks compared to Bt genotypes. The damage to fruiting bodies was very low (3.63%) in MECH-184 Bt followed by MECH-162 Bt (4.4%) and MECH-12 Bt (5.7%). In all the non-Bt hybrids and checks damage was significantly higher than respective transgenics. Such differences were also seen in damage caused to locules. Thus with only one need-based spray, the Bt hybrids outyielded the hybrids without Bt genes, through reduced incidence of bollworms, damage to fruiting bodies and higher retention of bolls. The yield recorded was highest (2.18 tons/ha) in MECH-184 Bt (12.46 q/ha in 184 non-Bt) which was not significantly different from MECH-12 Bt and MECH-162 Bt. The yield potential of MECH hybrids without Bt genes was low (12.46 to 13.65 q/ha) and not significantly different from the on par with checks despite of three applications of insecticides. Besides higher yields in Bt-hybrids, there was saving of two applications of insecticides and reduction in cost of protection to the extent of US $17 per hectare under Dharwad conditions.*


## Introduction

One hundred and eleven countries grow cotton as commercial crop. In India cotton is cultivated in a wide range of agro-climatic situations including low rainfall areas and irrigated areas under favorable conditions. India occupies 20 percent of the global cotton area and contributes 12 percent to world production (Anonymous, 2002). Tremendous benefits have been derived from pesticides in agriculture sector upon which Indian economy is largely dependent. Out of 169 million ha of permanently cropped area only five percent is covered by cotton. This receives 45 percent of India's insecticides on an array of sucking pests and bollworms, which attack cotton throughout the season. Bollworms alone cause more than US $23.5 million loss every year in India (Agarwal and Katiyar, 1979). Insecticides assume 76 percent of total pesticides used in India (Saiyed *et al.,* 1999). Management of insect pests through synthetic chemical insecticides was practiced as a boon in the advent era of green revolution. Sole reliance on insecticides, particularly pyrethroids, caused an imbalance in the agro-ecosystem and has created resistance to insecticides. Problems of insecticide resistance and resurgence have reached alarming stage warranting alternate control methods. Resistance to pyrethroids in India was found to be ubiquitous and stable at around 50-80 percent (Russell *et al.,* 1998), but dependence on cypermethrin and fenvelrate remain high (Anonymous, 2002). On an average, Indian farmers apply six to eight rounds of insecticides in rainfed situation and 12 to 18 rounds in irrigated situations (Kulkarni *et al.,* 2003). Out of this, 80 percent of insecticide applied targets bollworms only. As a correction to the ill effects caused by insecticides and with increasing awareness of environmental safety, the farming community is resorting to the transgenic crops world wide to minimize the use of pesticides. Transgenic cottons for bollworm tolerance now occupy a considerable area in USA, Australia and China (Khadi *et al.,* 2001) yielding tremendous benefits including savings in the costs of protection. With this background the estimation of the potential for insecticide use reduction sprays against bollworms in three Bt-cotton hybrids viz., MECH-162, MECH-12 and MECH-184, has been carried out in the present investigation.

## Experimental procedure

The experiment was conducted at Agricultural Research Station, Dharwad Farm, Dharwad (Karnataka, India), which is located at 678 MSL (15.7° N and 76.6° E). The average rainfall at Dharwad is 740 mm. Plots were 5.4 m and 5.6 m, replicated three times in a randomized block design. Plant spacing was 90 cm x 60 cm, giving 25 plants per treatment. The transgenic cultivars viz., MECH-162 Bt, MECH-184 Bt, MECH-12 Bt, the respective non-Bt genotypes and local commercial hybrids DHH-11, NHH-44 (checks) were sown during 2$^{nd}$ week of July in three replications under randomized block design. Seeds were treated with imidacloprid 70 WS @ 10 g/kg and two rounds of insecticides (imidacloprid 200 SL @ 100 ml/ha, acetamaprid 20

SP @ 50 g/ha) were applied uniformly in all treatments to check sucking pests. The sprays against bollworms were given based on an ETL 1.0 larvae plant. Hence there were three sprays against bollworms in the non-Bt genotypes and check hybrids. The applications included endosulfan 35 EC (3.0 l/ha), chlorpyriphos 20 EC (2.5 l/ha) and indoxacarb 15 SC (0.5 l/ha). In the Bt genotypes only one spray (indoxacarb 15 SC @ 0.5 l/ha) was necessary on the above ETL criteria. Season-long observations were made on the incidence of bollworm larvae/plant (*Helicoverpa armigera*, *Pectinophora gossypialla* and *Earias* spp.), damage to fruiting bodies, and the populations of predatory insects. The larvae and adults of coccinellids and larval stages of syrphids and chrysopa were monitored as predators. The data on these observations has been presented as seasonal means. The number of good opened bolls (GOB/plant), bad opened bolls (BOB/plant) and the seed cotton yield were also recorded. Data was analyzed using Duncan Multiple Range test with significance at 5%.

## Results and Discussion

### Incidence of Bollworms

Significantly lower incidence *H. armigera* was observed in all Bt genotypes compared to non-Bt and standard checks (Table 1). Among the Bt genotypes MECH-184 was found to be more tolerant, recording significantly lower incidence (0.45 larvae per plant) of *H. armigera* compared to other Bt genotypes. MECH-162 Bt was found to be next best genotype and significantly superior to the remaining genotypes. Spotted bollworm (*Earias* spp.) numbers were lower in all plots. Numbers in all Bt genotypes were very low (0.02/plant) but not significantly lower than in the non-Bt data for MECH-12, followed by non-Bt genotypes (0.04/plant). The standard checks NHH-44 and DHH-11 (0.31 and 0.38/plant respectively) were found to have significantly higher incidence of spotted bollworm (Table 1). The incidence of pink bollworm ranged from 1.33 to 6.67 per 10 bolls. MECH-162 Bt and MECH-12 Bt recorded significantly lower PBW, followed by MECH-184 Bt, which was significantly superior to the other treatments. MECH-12 non-Bt (6.67 per 10 bolls) and the check hybrid NHH-44 were found to be much susceptible All the three Bt genotypes recorded lower bollworm numbers compared to the respective non-Bt versions. However, there was variation between Bt genotypes.

### Fruiting body damage

Considering the damage caused by all the bollworms to fruiting bodies among these genotypes need based MECH 184 Bt was found to be the most promising (3.63% damage) followed by MECH-162 (4.26%). These were significantly superior to rest of the entries (Table 2). The check hybrids NHH-44 and DHH-11, and MECH-12 non-Bt were found to be more susceptible to bollworms. All the Bt genotypes recorded significant reduction in locule damage compared to the non-Bt genotypes and standard checks. Among the Bt genotypes, MECH-12 and MECH-162 were on par with each other in recording minimum locule damage followed by MECH-184. MECH-162 Bt recorded the highestGOB per plant (16.47), which was not significantly superior to MECH-184 Bt, but was not superior to NHH-44 and the other genotypes. There was very little diference in nuber of bad open bolls per plant amongst the non-Bt treatments. The Bt hybrids performed better, and equally well. The variation in bollworm population and damage between Bt cultivar may have been due to varied levels of expressed of toxin among cultivars and decline with advancement of the season. In MECH-12 Bt and MECH-184 the expression is high and slowly decline in expression (Kranthi, 2002). Bt-cottons normally control pink bollworm, which is difficult to manage with insecticides (Henneberry, *et al.*, 2001; Perlak *et al.*, 2001).

### Seed cotton yield (q/ha)

Perhaps due to the higher level and longer period of expression of their Bt protein, the cultivars MECH-184 Bt (2175 kg/ha) and MECH-12 Bt (2153 kg/ha) recorded significantly higher seed cotton yields when compared to the other genotypes and were statistically indistinguishable (Table 2). Seed cotton yield was 1858 kg/ha in MECH-162 Bt. All the non-Bt genotypes and commercial checks were similar to each other in the yield of seed cotton, and low compared to Bt hybrids. DHH-11 (1531 kg/ha) was the best of these.

### Natural enemy population

The results (Table 3) indicated that the population of syrphids, coccinellids and *Chrysoph* was the same in all treatments indicating that Bt genotypes did not affect the natural enemy population. The safety of Bt toxins/transgenic plants to predators and pollinators has been reported world-wide (Krattiger, 1997, Dayuan Xue, 2002, Cui and Xia, 1999).

### Avoidable sprays and economic analysis

With only one spray (indoxacarb 15 SC @ 0.5 l/ha) Bt genotypes out-yielded commercial conventional cultivars and the present respective genotypes without Bt genes, which received three sprays. The total savings in the cost of plant protection was USD 22.50 per hectare. Fifty to 90 percent reduction in insecticide use is expected in India (Kranthi, 2002). The reduction in present study was 66.66 percent. The major reason for acceptance of Bt transgenic crops, and especially Bt cotton, is the reduction in the cost of plant protection (Benbrook, 2001). Reduction in pesticide usage has been experienced by the farmers of China, USA, South Africa and Australia (Prey *et al.*, 2001; Carlson *et al.*, 1998; Ismael, 2002; Hubbell *et al.*, 2000). The advantage gained by utilization of Bt cottons depends upon the incidence of bollworms in the season and the quantity of insecticides used in conventional cultivars to protect the crop. In the present investigation the savings in cost of protection was not very great, which was due to the relatively low incidence of bollworms in the 2001-02 season. Similar variations in the cost of protection have been experienced in USA also, where the insect control costs in Bt cotton was slightly reduced during 1997, but significantly reduced in 1998 due to varing levels of budworm infestation (Cooke *et al.*, 2000).

## References


- Agarwal R.A. and Katiyar, K.N. (1979). An estimate of losses of seed kapas and seed due to bollworms on cotton in India. *Indian Journal of Entomology,* **41**: 1430-148.
- Anonymous, (2002). Cotton production practices, ICAC Report, Oct. 2002 pp. 9-15.
- Carlson, G.A. Marra, M.C. and Hubbell, B.J. (1998). Yield, insecticide use and profit changes from adoption of Bt cotton in the Southeast 1998 Proceedings Beltwide Cotton Conference, Son Diego, California, USA, 5-9 Jan 1998 pp. 2: 573-574.
- Benbrook, C. (2001). DO GM crops mean less pesticide use? Pesticide outlook,October, 2001, pp: 204-207.
- Cooke, F.T., Scott, , W.P, Meeks, R.D. and Parvin, D.W. (2000). The economic of Bt cotton in the Mississippi DeHa a progress report. 2000 Proceedings Beltwide cotton conference, San Antonio USA 4-8 January, pp. 332-334.
- Cui, J.J. and Xia, J.Y. (1999). Effect of transgenic Bt cotton on the population dynamics of natural enemies. *Acta Gossypii Sinica*, **11**: 84-91.
- Dayuan, X. (Eds.) (2002). A summary of research on the environmental impact of Bt cotton in China. Greenpeace, Nanjing p. 26.
- Perlak , F.J., Oppenhcizen, M., Gustafson, K., Voth, R., Sivasupramaniam, S., Heering, D., Carey, B. Robert A. 1 hrig and Roberts, J.K. (2001). Development and commercial use of Bollgard cotton in the USA – early promises versus today's reality. *The Plant Journal*, **27**: 489-501.
- Henneberry, T.J., Farlow Tech L. and De la Torre, T. (2001). Effects of transgenic cotton on mortality and development of pink bollworm larvae. *South Western Entomologist*, **26**: 115-128.
- Hubbell, B.J., Marra, M.C. and Carlson, G.A. (2000). Estimating the demand for new technology; Bt cotton and insecticide policies. *American Journal of Economics*, **82**: 118-132.
- Ismael, Y., Bennett, R. and Morse, S. (2002). Farm level economic impact of biotechnology: Small holder Bt cotton farmers in South Africa, *Outlook on Agriculture*, **31**: 107-111.
- Khadi, B.M., Kulkarni, V.N., Katageri, I.S. and Vamadevaiah, H.M. (2001). Role of transgenics in improving quality and quantity of cotton. *National Journal of Plant Improvement*, **3**: 11-23.
- Kranthi, K.R. (2002). Modalities of Bt cotton cultivation in India, its pros. and cons including resistance management and potential ecological impact in Proceedings of National Seminar on Bt cotton scenario with special reference to India 23rd March 2002, UAS, Dharwad, India, pp.26-50.
- Krattiger, A.F. (1997). Insect Resistance in crops: a case study of Bacillus thuringiensis (Bt) and its transfer in developing countries. *ISAAA Briefs No*. 2 ISAAA: Ithica N. pp. 42.
- Kulkarni, K.A., Patil, S.B. and Udikeri, S.S. (2003). Strategy of sustainable insect pest management of cotton pests. A scenario in Karnetaka. Proceedings of National Symposium on Sustainable Insect Pest Management. Entomological Research Institute, Loyola College, Chennai, India. Feb. 6-7, 2003. pp.3-4.
- Prey C., Ma Dan Meng, Huang Ji Kun and Qiao Fang Bin (2001). Impact of Bt cotton in China. *World Development,* **29**: 813-825.
- Russell, D.A., Singh, J., Jadhav, D.R., Surulivelu, T., Regupathy, A. and Kranthi, K.R. (1998). Management of insecticide resistant *Helicoverpa armigera* (Lepidoptera:Noctuidae) in cotton in India Procceeding of World Cotton Research Conference-2. Athense, Greece, Sept. 6-12 1998 p.679-688.
- Saiyed, H.N., Bhatnagar, V.K. and Kashyap, R. (1999). Impact of pesticide use in India. *Asian-Pacific News Letter,* No.3.

***Table 1.*** *Mean number of of bollworms in Bt transgenic and control cultivars under need-based spraying.*

| Treatments | Bollworm population (larvae)* | | |
|---|---|---|---|
| | *Helicoverpa*/plant | *Earias* spp./plant | PBW/10 bolls |
| MECH 12 Bt | 0.90 e | 0.02 c | 1.33 e |
| MECH 12 Non-Bt | 1.48 b | 0.02 c | 4.33 c |
| MECH 162 Bt | 0.63 f | 0.02 c | 1.33 e |
| MECH 162 Non-Bt | 1.80 a | 0.04 c | 6.67 a |
| MECH 184 Bt | 0.45 g | 0.02 c | 2.00 d |
| MECH 184 Non-Bt | 1.38 c | 0.04 c | 4.67 c |
| DHH-11 | 1.73 ab | 0.38 a | 5.30 b |
| NHH-44 | 1.05 d | 0.31 b | 6.33 a |

* Values with the same alphabetical letter in a column do not differ significantly by DMRT (P= 0.05).

***Table 2.*** *Damage due to bollworms and yield in Bt transgenic and control cultivars under need-based spraying.*

| Treatments | Damage to fruiting bodies (%) | Locule damage (%) | GOB/plant | BOB/plant | Yield (kg/ha) |
|---|---|---|---|---|---|
| MECH 12 Bt | 5.66 c | 10.24 f | 13.63 bc | 1.23 e | 2153 a |
| MECH 12 Non-Bt | 6.58 b | 38.77 d | 10.23 e | 3.37 ab | 1252 c |
| MECH 162 Bt | 4.36 e | 11.30 f | 16.47 a | 1.37 e | 1858 ab |
| MECH 162 Non-Bt | 5.06 d | 54.13 a | 11.50 cde | 3.60 a | 1365 c |
| MECH 184 Bt | 3.63 f | 17.83 e | 14.57 ab | 1.63 de | 2175 a |
| MECH 184 Non-Bt | 4.27 e | 44.27 c | 12.83 bcd | 3.00 abc | 1246 c |
| DHH-11 | 6.58 b | 47.26 b | 11.13 de | 2.37 cd | 1531 bc |
| NHH-44 | 7.32 a | 46.56 bc | 14.63 ab | 2.53 bc | 1331 c |

Values followed by the same alphabetical letter in a column do not differ significantly by DMRT (P= 0.05)

***Table 3.*** *Insect predator population in protected conditions of Bt cotton genotypes and other cultivars.*

| Treatments | Natural enemy population/plant | | |
|---|---|---|---|
| | Syrphids | Coccinellids | Chrysopa |
| MECH 12 Bt | 0.13 a | 1.67 a | 0.53 a |
| MECH 12 Non-Bt | 0.20 a | 1.60 a | 0.67 a |
| MECH 162 Bt | 0.20 a | 1.00 a | 0.47 a |
| MECH 162 Non-Bt | 0.13 a | 1.33 a | 0.40 a |
| MECH 184 Bt | 0.20 a | 1.67 a | 0.53 a |
| MECH 184 Non-Bt | 0.27 a | 1.00 a | 0.40 a |
| DHH-11 | 0.13 a | 0.93 a | 1.00 a |
| NHH-44 | 0.27 a | 1.13 a | 0.27 a |

Values followed by the same alphabetical letter in a column do not differ significantly by DMRT (P= 0.05).